Listing of the Claims

This listing of the claims will replace all prior versions, and listings, of claims in the Application:

1. (Original) A method for determining vibration amplitude limits to detect faults in mechanical equipment, comprising:

estimating a data probability distribution based on data for the mechanical equipment; and

utilizing the data probability distribution to calculate the vibration amplitude limits.

2. (Original) The method of Claim 1 further comprising removing outlier data.

3. (Currently Amended) ~~The method of Claim 2 further comprising~~ A method for determining vibration amplitude limits to detect faults in mechanical equipment, comprising:

estimating a data probability distribution based on data for the mechanical equipment;

utilizing the data probability distribution to calculate the vibration amplitude limits;

removing outlier data; and

calculating the vibration amplitude limits as a function of frequency for a substantial portion of the frequency spectrum.

4. (Currently Amended) The method of Claim 3 [[1]] wherein the data probability distribution is calculated using statistics and historical data of the mechanical equipment.

5. (Original) The method of Claim 4 further comprising specifying importance levels for certain frequencies.

6. (Original) The method of Claim 5 wherein the certain frequencies comprise frequencies for at least one of a motor, a compressor, or a gear.

7. (Original) The method of Claim 6 further comprising obtaining vibration spectra comprising individual spectrum for the mechanical equipment from a database.

8. (Original) The method of Claim 7 further comprising calculating a frequency for the individual spectrum and identifying the individual spectrum having a smallest number of frequency lines.

9. (Original) The method of Claim 8 further comprising calculating noise bandwidths and a largest noise bandwidth.

10. (Original) The method of Claim 9 further comprising collecting vibration data from all spectra in a given frequency range.

11. (Original) The method of Claim 4 wherein the data probability distribution is calculated using a kernel density method.

12. (Original) The method of Claim 11 wherein the kernel density method comprises calculating conditional kernel density.

13. (Original) The method of Claim 12 wherein calculating conditional kernel density comprises estimating an unknown probability density for a given dataset.

14. (Original) The method of Claim 13 wherein the probability density estimate at a point x for a one-dimensional dataset with n data points is given by:

$$p(x) = \frac{1}{n\,h}\sum_{j=1}^{n} \kappa\left(\frac{x - x_j}{h}\right)$$

where, x_j is the j^{th} observation of dataset X, h is a bandwidth that characterizes a spread of the kernel, and $\kappa(\cdot)$ is a kernel density function that is symmetric and satisfies the condition: $\int_{-\infty}^{\infty} \kappa(u)du = 1$.

15. (Original) The method of Claim 14 wherein the kernel density estimate is a two-dimensional kernel density estimate utilizing frequency and amplitude directions of the frequency spectrum.

16. (Original) The method of Claim 15 wherein a d-dimensional kernel density estimate is generally written as:

$$p(x) = \frac{1}{n}\sum_{j=1}^{n} |H|^{-1/2} \mathrm{K}\left(H^{-1/2}(x - x_j)\right)$$

where $\mathrm{K}(u)$ is a d-dimensional kernel, H is a bandwidth matrix, and $|\cdot|$ denotes a matrix determinant.

17. (Original) The method of Claim 4 further comprising detecting one or more faults in the mechanical equipment.

18. (Currently Amended) The method of Claim <u>3</u> [[1]] wherein the mechanical equipment comprises one or more HVAC chillers.

19. (Original) A method for detecting faults in a chiller based on vibration amplitude limits, comprising:

calculating vibration amplitude limits of the chiller using statistics and historical data for the chiller;

estimating an at least two-dimensional density estimate; and

weighting the historical data based on when the historical data was generated;

wherein the vibration amplitude limits are calculated as a function of frequency for an entire frequency spectrum.

20. (Original) The method of Claim 19 further comprising removing outlier data.

21. (Original) The method of Claim 20 wherein the at least two-dimensional density estimate utilizes frequency and amplitude directions of the frequency spectrum.

22. (Original) The method of Claim 21 wherein the at least two-dimensional density estimate is a d-dimensional kernel density estimate.

23. (Original) The method of Claim 22 wherein the d-dimensional kernel density estimate for point x of a dataset with n data points is given by:

$$p(x) = \frac{1}{n}\sum_{j=1}^{n}|H|^{-1/2}\mathrm{K}\left(H^{-1/2}(x - x_j)\right)$$

where, x_j is the j^{th} observation of the dataset, $\mathrm{K}\,(u)$ is a d-dimensional kernel, H is a bandwidth matrix, and $|\cdot|$ denotes a matrix determinant.

24. (Original) The method of Claim 22 further including obtaining vibration spectra comprising individual spectrum for the chiller from a database.

25. (Original) The method of Claim 24 further comprising calculating a frequency for the individual spectrum and identifying an individual spectrum having the smallest number of frequency lines.

26. (Original) The method of Claim 25 further comprising calculating noise bandwidths and a largest noise bandwidth.

27. (Original) The method of Claim 26 further comprising collecting vibration data from all spectra in a given frequency range.

28. (Original) The method of Claim 19 further comprising calculating a conditional kernel density.

29. (Original) The method of Claim 28 wherein calculating the conditional kernel density comprises estimating an unknown probability density for a given dataset.

30. (Original) A method for determining vibration amplitude limits of a mechanical device comprising:

identifying a mechanical device and a frequency range for a spectrum to be analyzed;

retrieving vibration spectra comprising individual spectrum for the mechanical device and the frequency range;

calculating frequency for the individual spectrum;

identifying the individual spectrum with a smallest number of frequency lines;

calculating noise bandwidths and a largest noise bandwidth;

removing outlier data;

calculating conditional kernel density; and

calculating vibration amplitude limits to detect faults in the mechanical device.

31. (Original) The method of Claim 30 wherein the mechanical device comprises a chiller for an HVAC system.

32. (Original) The method of Claim 30 wherein the vibration spectra for the mechanical device and the frequency range is obtained from a database.

33. (Original) The method of Claim 32 wherein calculating conditional kernel density comprises estimating an unknown probability density for a given dataset.

34. (Original) The method of Claim 33 wherein the probability density estimate at a point x for a one-dimensional dataset with n data points is given by:

$$p(x) = \frac{1}{nh} \sum_{j=1}^{n} \kappa\left(\frac{x - x_j}{h}\right)$$

where, x_j is the j^{th} observation of the dataset, h is a bandwidth that characterizes a spread of the kernel, and $\kappa(\cdot)$ is a kernel density function that is symmetric and satisfies the condition: $\int_{-\infty}^{\infty} \kappa(u) du = 1$.

35. (Original) The method of Claim 33 wherein the kernel density estimate is at least a two-dimensional kernel density estimate utilizing frequency and amplitude directions of the frequency spectrum.

36. (Original) The method of Claim 35 wherein a d-dimensional kernel density estimate is given by:

$$p(x) = \frac{1}{n} \sum_{j=1}^{n} |H|^{-1/2} \mathrm{K}\left(H^{-1/2}(x - x_j)\right)$$

where $\mathrm{K}(u)$ is a d-dimensional kernel, H is a bandwidth matrix, and $|\cdot|$ denotes a matrix determinant.